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SEARCH FOR ANTIMATTER IN COSMIC RAYS AND IN

COSMIC SPACE

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SEARCH FOR ANTIMATTER IN COSMIC RAYS AND IN COSMIC SPACE

(Poiski antiveshchestva v kosmicheskikh luchakh i v kosmicheskom prostranstve)

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Cosmic ray particles "live" in the Galaxy some 10^8 years. During their "lifetime" they move along a path of the order of 10^{26} cm, i.e. particles reaching the Earth may originate from the most various, and at the same time, most remote parts of the Galaxy. It is not ruled out, that some part of cosmic radiation may be of metagalactic origin. This allows us to assume that the study of primary cosmic rays may provide a specific information about the antimatter, at least in our Galaxy.

Inasmuch as in the processes of primary cosmic ray particles' interaction with the matter scatter in the Galaxy, antinucleons may be born, so the antiproton detection in the primary cosmic ray content has not yet been able to provide a unilateral answer to the question of existence of antimatter in cosmic rays. At the same time, the revelation of the complex nucleus, made of antinucleons would be a unilateral demonstration of the presence of antimatter in the Universe.

From the experimental viewpoint, the antinucleus can reliably be distinguished in photoemulsion from the usual nucleus only at low antinucleus kinetic energies (in comparison with the energy of the rest mass). In that case, the orducts of nucleus annihilation will be endowed with an aggregate energy substantially greater than the kinetic energy of the primary multi-charge particle (antinucleus). That is why, in order to achieve a reliable identification of antinuclei in the primary cosmic radiation, their search must be carried out among multi-charge nuclei stopping on the emulsion.

At the same time, another distinction in the antinucleus behavior in comparison with nuclei is being revealed. It is well known, that in the nuclear photoemulsion, the wake of the multi-charge particle is thinning near the point of particle's stopping. This is explained by electron capturing by the particle, and by a decrease of the effective charge of the particle as its velocity decreases. The antinucleus must have a negative electric charge. Thus, the antinucleus' deceleration in the matter will not be attended by electron capture and by a decrease of antinucleus' effective charge. Consequently, the density of the ionization created by the antinucleus, will be growing through the very stopping according to the Breg curve. At the end of the wake of the stopped antinucleus, an annihilation "star" must be observed, with an isotropic particle distribution in the laboratory system of coordinates.

An emulsion pile was placed by us on the second cosmic spaceship. It contained 489 layers of the type BR emulsion, whose dimension were 10 x 10 cm^2 and the tickness — 400 mk. The pile was exposed beyond the atmosphere at about 300 km heights, and in the course of some 24 hours. Upon return to the ground and its chemical processing, the pile was the object of a thorough checking. This was carried out with the aid of MBI-2 microscopes with a 105 X magnification. During the examination, the multi-charge nuclei and "stars", created by the multi-charge nuclei, that stopped in the emulsion were fixed. Because the viewing was carried out with a small magnification, the primary α-particles were not practically registered, and only particles with $Z > 2$ were sorted.

420 such stopped usual nuclei (with a thinning at the end of the wake) and 320 "stars" were found in a 656 cm^3 volume of emulsion. Not one of the "stars" showed to posses peculiarities that are characteristic of the annihilation of a stopped multi-charge particle.

If we assume that antinuclei have the same energy spectrum as do the usual nuclei, the ratio of the stopped antinuclei to the total number of the stopped multi-charge particles would be equal to the ratio of antinuclei to the total multi-charge cosmic particle flux. Since for 442 stoppings of multi-charge nuclei we failed to find a ~~single~~ stopped antinucleus, it follows from our data that the ratio of antinuclei with $Z > 2$ in cosmic rays does not exceed 0.23 percent of the usual nuclei with the same charge. A similar result was obtained in reference [1].

Had the antimatter been scattered in the solar system in the form of separate atoms, the estimate of the upper boundary for antimatter's density might in that case be obtained in the following manner:

During its motion around the Sun, and on account of its velocity of the order of 30 km $\cdot$ sec^{-1}, The Earth will "collect" all the antimatter found in its path. Annihilating with the substance of the atmosphere somewhere at 10^2 to 10^3 km heights, this antimatter shall create an isotropically distributed annihilating radiation out of π^0 and $\pi^{\pm}$ - mesons, i.e. from γ-quanta and electrons with energies of the order of 10^8 eV in the long run.

Let $\bar{\rho}_a$ - be the mean density of antimatter in the solar system. All antimatter, situated in column 30 km long and 1 cm^2 in cross section, falls on a surface of the terrestrial atmosphere of 1 cm^2, per second, i.e. there occurs an annihilating γ- quantum radiation of intensity

$$\frac{3\cdot 10^5\cdot 2\bar{n}_{\pi^0}\bar{\rho}_a}{1{,}6\cdot 10^{-24}} \approx 4\cdot 10^{30}\,\bar{n}_{\pi^0}\bar{\rho}_a \text{ quanta cm}^{-2}\text{ sec}^{-1},$$

where $\bar{n}_{\pi^0}$ is the mean number of π^0 mesons formed at antinucleus'annihilation. Half of that flux will flow toward the Earth. Thus the γ- quantum flux with an energy of the order of 10^8 eV will be

$$J_\gamma \approx 2\cdot 10^{30}\,\bar{n}_{\pi^0}\bar{\rho}_a \text{ cm}^{-2}\cdot\text{sec}^{-1}.$$

We may take as the uppermost estimate of J_γ (apparently much overrated) a flux that would create a charged particle flux with an energy $E \gg 10^8$ eV registrable at the 4^0 geomagnetic latitude [2], provided we consider that all these particles are electrons. From that estimate, we shall obtain $J_\gamma < 10^{-1}\text{ cm}^{-2}\text{sec}^{-1}$ and $\bar{\rho}_a < \frac{1}{3} 10^{-31}\text{g}\cdot\text{cm}^{-3}$.

If we consider that the density of the matter in the solar system is

$$\bar{\rho} \sim 10^{-24} g \cdot cm^{-3},$$

we then have

$$\frac{\rho_\alpha}{\bar{\rho}} < \frac{1}{3} 10^{-7}.$$

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***** E N D *****

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R E F E R E N C E S

1. D. M.KHASKIN, P. L. DZHYN, E. LORMAN, M. SHAYN, M. TOYKHER. Trudy Mezhdunarodnoy konferentsii po kosmicheskim lucham, T. III, p.138, Izd-vo A.N. SSSR, 1960.

2. F. B. Mc DONALD. Nuovo Cimento Suppl. , 8, 500, 1958.

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